PROJECT

MONSTER CARS

OBJECTIVE

The purpose of this lesson is have students understand how rate (slope) is calculated from two data points. This is done by collecting data (time, distance) on battery operated cars. The students will also relate the y-intercept to the starting point of the car. This activity also offers a context for the students to understand the variables and various solutions of the equation that they will be learning to write.

Concepts
Rate; y-intercept; writing, solving and graphing equations of lines in slope-intercept form

Time: 3-4 hours

Materials
Battery operated cars (two types/speeds for each group of students), stop watches, student handout, graph paper.

Preparation
Find a venue for the lesson, and establish the "race course" by placing masking tape at the designated intervals.

ESTABLISHING THE RACE COURSE

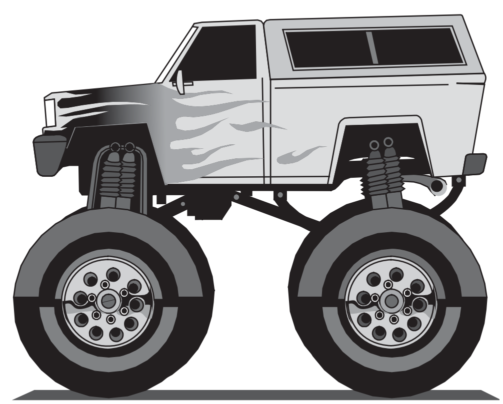
The cars need a smooth flat surface (classroom carpet, or hallway floor) that is about twenty feet long and about ten feet wide. Choose a place where the students can take measurements, record data, and complete calculations. The classroom works best if there is enough room. On the floor, place seven parallel lines of masking tape every three feet. Write the assigned distance on each line, ranging from -6 feet to 12 feet. (See diagram on student handout.)

Assign students to pairs or groups. When the students are timing the cars, make sure that the person starting the car says go, and then the timekeeper starts the watch. If the timekeeper says go, there will be a lag before the car is actually released.

PART ONE: Finding the Rate of the Car

The students start the car at the starting line (distance of zero), and time the car to the first mark (3 feet). They should record this data as an ordered pair. For example, if the car took 1.5 seconds to get to the first mark, this data would be represented as (1.5, 3). The group should time the car again, this time to the second mark and record the data, again as an ordered pair. The first mark is then used to calculate the rate of the car. In our example above, the car traveled 3 feet in 1.5 seconds, or at a rate of 2 feet per second. The rate is then calculated using the second data point. The two calculated rates should be nearly equal.

Writing the equation to relate the car's distance to time follows the well-known formula: $d= rt$. For our hypothetical car, the students should write $d = 2t$. This equation is then used to answer the next two questions. In order to predict the distance that the car will travel in 10 seconds, we substitute 10 in for t and find that the car should travel 20 feet. In order to predict the time it will take the car to reach the third mark, the students should substitute 9 in for d, and get a time of 4.5 seconds. Once the students have calculated their predictions algebraically (showing all their work, of course), then they are to test their predictions by timing the car for 10 seconds, and timing how long it takes the car to reach the third mark.



For the graph, the students should plot the four ordered pairs that they produced for the lesson. The points will nearly form a straight line, although error in the data collection may produce some slight variance. The students will get the point though: the equation is linear because the car's rate is constant. The class discussion should center around the following concepts: 1) the slope of the line, the coefficient of x and the rate of the car are all the same thing, 2) the y-intercept is zero because the car started at the starting line, 3) the domain and range of the data determine the scales for the axes.

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LESSON PLAN (continued)

PART TWO: Finding the Starting Point of the Car

This next phase focuses on calculating the slope from two data points (rather than one) and on calculating the y-intercept. The students are now to time a different car, beginning at a location other than the starting line. Mark the starting point of each car with a piece of masking tape, and mark the tape with a number designating the group. Note that now the distance will be recorded in inches, and the time will be recorded for the first and the third mark. When the students attempt to find the rate, though, many of them will make the mistake of using the two data points separately, as was done with the previous car, rather than finding the difference between the two points. This is exactly the mistake that we hope they make! This common error offers the prime teachable moment: Did the car really travel the entire distance of the mark in the recorded time?

For example, let us assume that a car starts an unknown distance in front of the starting line, and reaches the first mark in one and a half seconds, and reaches the third mark in ten and a half seconds. This would yield the following data points: (1.5, 36) and (10.5, 108). We can show the students that, no, the car did not travel all 36 inches in 1.5 seconds, nor did it travel all 108 inches in 10.5 seconds. Where on the course, then, can we find a corresponding distance and time? Between the two marks! Yes, and we can find that distance and time by subtracting the coordinates of the data points. The car actually traveled 72 inches (108 - 36) in 9 seconds (10.5 - 1.5). By dividing as we have before we get a rate of 8 inches per second. The students are then prompted to formalize this process with an equation: $m = (y_2 - y_1)/(x_2 - x_1)$

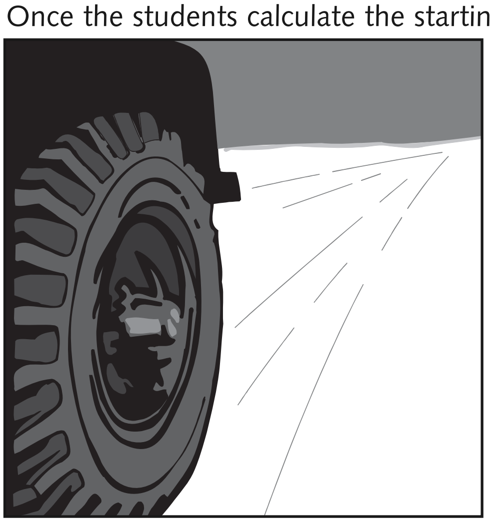
Once the students calculate this rate, they will then be asked to find the car's starting point. Allow the students to wrestle with this one for awhile, until they understand that they can figure the distance forward to the first mark, then subtract to get the distance backward to the starting line. In our example, the car traveled at 8 in/sec for 1.5 seconds, which means, it traveled 12 inches. Therefore, it started 24 inches in front of the starting line. The students will follow the reasoning rather easily, but they must be pressed to communicate it algebraically and to write the equation as follows.

$$M = \frac{108 - 36}{10.5 - 1.5} = \frac{72}{9} = 8$$

$$36 = 8(1.5) + b$$
$$36 = 12 + b$$
$$24 = b$$

$$d = 8t + 24$$

Once the students calculate the starting point, they should use a ruler to measure the actual starting distance. They will be impressed by their own accuracy. In the subsequent questions, making the predictions, taking the actual measurements and drawing the graphs are all handled similarly to those with the first car. The obvious point of emphasis here is the relation of the y-intercept to the starting distance of the car.



PART THREE: Starting Behind the Starting Line

If possible, have the students use a different car (different rate) for the final phase of the lesson. This phase runs identically to the previous one, with the simple exception that the car begins behind the starting line yielding a negative y-intercept. Again, push them to show the calculations algebraically.

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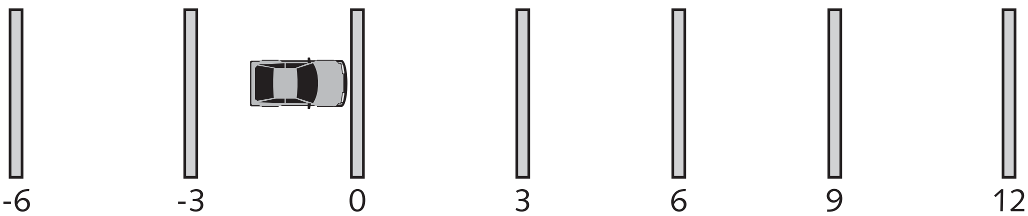
You have a toy car. Determine its speed, and use that data to determine other valuable information of the car. Gather your data using the established race course. Each mark is 3 feet apart as shown in the diagram below.



PART ONE: Finding the Rate of the Car

1. Place Car #1 on the starting line and time how long it takes to reach the first mark. Repeat this process for the second mark. Write the data as an ordered pair (t, d).

1st Mark	**2nd Mark**
(,)	(,)

2. Calculate the rate of the car twice, once with your first data point, then again with the other. If the two rates differ dramatically, feel free to time your car again.

Rate: ________ ft/sec (1st mark) **Rate:** ________ ft/sec (2nd mark)

3. Write an equation to represent the relationship of the car's distance, d, to time, t. ______________________

4. Use your equation to predict how far the car will go in 10 sec. Then test your result.

Prediction: (,) **Actual Distance:** ____________

5. Use your equation to predict how long it would take to get to the third mark. Test your result.

Prediction: (,) **Actual Time:** ____________

6. Graph your data points from numbers 1, 4, & 5. Draw a line through these data points. Show the slope of the line. How does this relate to your answer in number 2? What does the y-intercept of the graph represent?

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PART TWO: Finding the Starting Point of the Car.

7. Place Car #2 somewhere between the starting line and the first mark. Time how long it takes the car to get to the first mark. Then place the car at the same starting point and time how long it takes to reach the third mark. Write the data as an ordered pair (t, d).

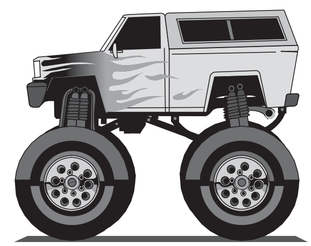
1st Mark	**3rd Mark**
(,)	(,)

8. Calculate the rate of the car. Then start the car at the starting line and test your prediction.

Prediction	**Actual**
Rate: __________ in/sec	**Rate**: __________ in/sec

9. Describe how to calculate rate when the starting point is not the starting line, given two data points.

10. Write a formula to represent your explanation above. ____________________



11. Calculate the starting point of the car, then measure the actual starting point.

Calculated: __________ **Measured:** __________

12. Write an equation to represent the relationship of the car's distance, d, to time, t. __________

13. Use your equation to predict how far the car will go in 15 sec.

Prediction: (,   ) **Actual Distance:** __________

14. Use your equation to predict how long it would take to get to the second mark. Test your result.

Prediction: (,   ) **Actual Time:** __________

15. Graph your data points from numbers 7, 11, 13, & 14. Draw a line through these data points. Show the slope of the line. How does this relate to your answer in number 8? What does the y-intercept of the graph represent? How does it relate to your answer in number 9?

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PART THREE: Starting Behind the Starting Line

16. Place Car #2 somewhere BEHIND the starting line, but not at any of the established marks. Determine two data points (t, d).

1st Point	2nd Point
(,)	(,)

17. Calculate the rate of the car.

Rate: __________ in/sec

18. Calculate the starting point of the car, then measure the actual starting point.

Calculated: __________ **Measured:** __________

19. Write an equation to represent the relationship of the car's distance, d, to time, t. ____________________

20. Use your equation to predict how far the car will go in 15 sec.

Prediction: (,) **Actual Distance:** __________

21. Use your equation to predict how long it would take to cross the starting line. Then test your result. Where is this point on the graph?

Prediction: (,) **Actual Time:** __________

22. Graph your data points from numbers 16, 20, & 21. Draw a line through these data points. Show the slope of the line. How does this relate to your answer in number 17? What does the y-intercept of the graph represent? How does it relate to your answer in number 18?